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National Eutrophication Survey, Corvallis, Oreg

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

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Report
on
Somerville Lake
Burleson, Lee and Washington Counties
Texas
EPA Region VI
Working Paper No. 659

With the cooperation of the
Texas Water Quality Board
and the
Texas National Guard
March, 1977

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16. ABSTRACT:

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

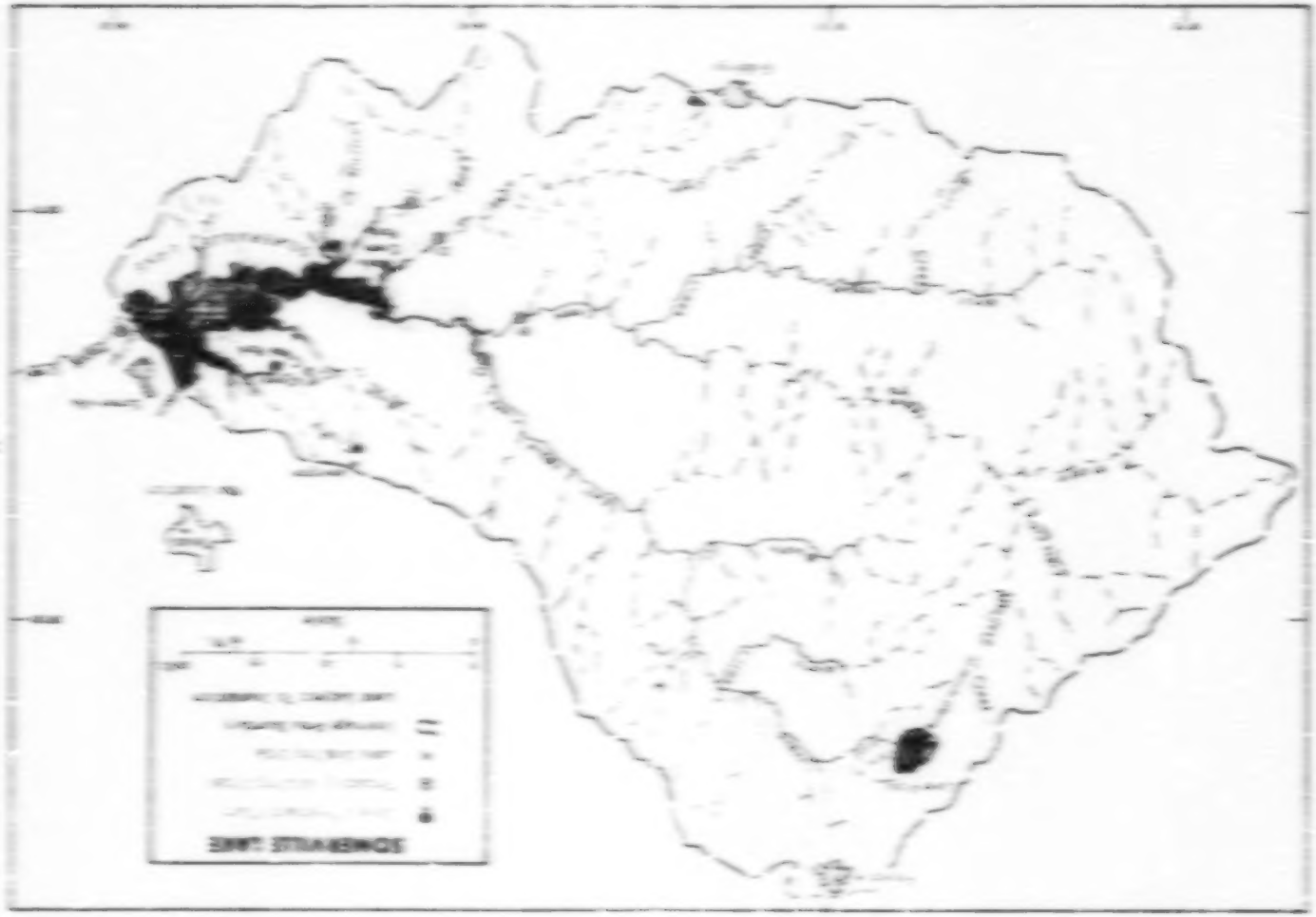
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
T. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass



SOMERVILLE LAKE

STORET NO. 4829

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Somerville Lake is eutrophic; i.e., well supplied with nutrients and quite productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the lake. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of this water body.

Somerville Lake ranked thirty-first when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six parameters*. Twenty-seven of the reservoirs had less median total phosphorus, 25 had less and three had the same median dissolved orthophosphorus, 17 had less median inorganic nitrogen, 37 had less mean chlorophyll a, and 29 had greater mean Secchi disc transparency. Depression of dissolved oxygen with depth occurred at station 2 in May and at station 1 in August.

Survey limnologists observed submerged aquatic plants at stations 1 and 2 in May, and blue-green algae were dominant in the August phytoplankton sample.

B. Rate-Limiting Nutrient:

The results of the algal assay indicate that Somerville Lake was phosphorus limited in March but nitrogen limited in November.

* See Appendix A.

The lake data indicate phosphorus limitation in March and May and nitrogen limitation in November.

C. Nutrient Controllability:

1. Point sources--The point-source phosphorus contributions amounted to 15.1% of the total load reaching Somerville Lake during the sampling year. Lexington contributed 1.8% of the total; Giddings, 6.4%; Rocky Creek Park, 4.3%; and Big Creek Park added 2.6% of the total. In addition, the City of Rockdale is in the Lake Sommerville drainage (Wyatt, 1976). However, this source is well beyond the 40-kilometer Survey limit*, and phosphorus contributions from this source probably are not significant as indicated by the relatively low export rate of East Yegua Creek (see discussion below).

The present phosphorus loading of 0.54 $g/m^2/yr$ is only a little more than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 16). However, the data indicate that Somerville Lake is eutrophic, and it is possible that the point-source phosphorus contributions directly to the lake were underestimated. Further study is needed to quantify the point-source phosphorus contribution to Somerville Lake.

2. Non-point sources--Non-point sources contributed 84.9% of the total phosphorus load during the sampling year. Middle and East Yegua Creek contributed 30.9% and 12.5% of the load, respectively.

* See Working Paper No. 175, "...Survey Methods, 1973-1976".

The phosphorus export rates of Middle Vegua Creek, East Vegua Creek, Nails Creek, and Cedar Creek were 7, 4, 14, and 10 kg/km^2/yr, respectively. The rates of Middle and East Vegua Creek are quite comparable to the rates of tributaries of other reservoirs in the vicinity, but the export rates of Nails Creek and Cedar Creek are significantly higher. These higher rates may be due to unidentified point sources rather than to non-point source inputs.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 46.38 kilometers².
2. Mean depth: 4.3 meters.
3. Maximum depth: >7.9 meters.
4. Volume: 197.496 x 10^6 m^3.
5. Mean hydraulic retention time: 0.6 years (based on 1972-1976 mean outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Middle Yegua Creek	1,131.8	2.815
East Yegua Creek	714.8	1.500
Nails Creek	181.6	0.990
Cedar Creek	123.3	0.[illegible]05
Minor tributaries & immediate drainage -	360.5	1.810
Totals	2,512.0	7.920

2. Outlet -

Brenham aqueduct	0.0	0.060**
Yegua Creek	2,610.7	6.530
Totals	2,610.7***	6.590***

C. Precipitation****:

1. Year of sampling: 119.0 centimeters.
2. Mean annual: 101.4 centimeters.

† Table of metric conversions--Appendix B.
†† Barrows, 1977.
* For limits of accuracy, see Working Paper No. 175.
** Howard, 1976.
*** Includes area of lake; lesser outflow due to evaporation.
**** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Somerville Lake was sampled four times in 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two or more depths at three stations on the lake (see map, page vi). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was composited from each of the stations for chlorophyll a analysis. The maximum depths sampled were 7.9 meters at station 1, 3.4 meters at station 2, and 1.5 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table (the August nutrient samples were not preserved properly and were not analyzed).

A SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR SPRINGVILLE LAKE
STORET CODE [illegible]

PARAMETER	157 SAMPLING [illegible] 3 SITES RANGE	MEAN	MEDIAN	245 SAMPLING [illegible] 3 SITES RANGE	MEAN	MEDIAN	365 SAMPLING [illegible] 3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	25.4 - 28.2	26.9	26.8	24.5 - 27.9	27.2	27.3	27.5 - 30.4	29.0	28.9
DISS OXY (MG/L)	7.6 - 8.4	7.9	8.0	3.8 - 8.0	6.2	6.0	3.8 - 10.9	7.1	7.4
OXY SAT (PERCENT)	88% - 97%	93%	94%	34% - 94%	66%	67%	43% - 97%	82%	84%
PH (STAND UNITS)	7.7 - 7.8	7.8	7.8	7.2 - 7.9	7.4	7.5	7.8 - 9.0	8.5	8.4
TOT ALK (MG/L)	45 - 54	50	49	51 - 54	52	52	[illegible]	[illegible]	[illegible]
TOT P (MG/L)	0.049 - 0.104	0.064	0.055	0.024 - 0.137	0.053	0.039	[illegible]	[illegible]	[illegible]
DISS P (MG/L)	0.013 - 0.025	0.021	0.021	0.003 - 0.015	0.006	0.005	[illegible]	[illegible]	[illegible]
NO2+NO3 (MG/L)	0.040 - 0.260	0.095	0.038	0.002 - 0.040	0.012	0.009	[illegible]	[illegible]	[illegible]
AMMONIA (MG/L)	0.040 - 0.070	0.054	0.055	0.040 - 0.200	0.069	0.070	[illegible]	[illegible]	[illegible]
KJEL N (MG/L)	0.400 - 1.000	0.625	0.550	0.500 - 1.700	0.600	0.600	[illegible]	[illegible]	[illegible]
INORG N (MG/L)	0.040 - 0.430	0.221	0.210	0.040 - 0.250	0.152	0.140	[illegible]	[illegible]	[illegible]
TOTAL N (MG/L)	0.750 - 1.050	0.850	0.855	0.570 - [illegible]	0.752	0.660	[illegible]	[illegible]	[illegible]
CHLOPHYL A (MG/L)	6.9 - 38.9	25.5	23.6	5.9 - 13.2	8.6	8.9	33.8 - 53.7	43.9	43.5
SECCHI (METERS)	0.3 - 0.5	0.4	0.4	0.8 - 1.2	0.9	1.1	0.3 - 1.0	0.7	0.9

A SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR SURFACE LAKE
STUDY [illegible]

[illegible] SAMPLING [illegible]

PARAMETER	3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	17.8 - 28.7	25.6	25.6
DISS OXY (MG/L)	6.8 - 8.4	7.6	7.6
CNDCTVY (MICROMH)	255. - 278.	262.	264.
PH (STAND UNITS)	6.7 - 7.4	7.2	7.2
TOT ALK (MG/L)	35. - 44.	39.	38.
TOT P (MG/L)	0.046 - 0.125	0.069	0.059
SRTHO P (MG/L)	0.009 - 0.029	0.014	0.013
NO2+NO3 (MG/L)	0.025 - 0.048	0.034	0.033
AMMONIA (MG/L)	0.040 - 0.109	0.062	0.060
KJEL N (MG/L)	0.400 - 1.000	0.731	0.700
ORG N (MG/L)	0.350 - 0.939	0.667	0.648
TOTAL N (MG/L)	0.429 - 1.039	0.734	0.726
CHLOPHYL A (UG/L)	25.1 - 33.4	28.2	28.2
SECCHI (METERS)	6.5 - 8.4	8.0	8.0

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/14/74	1. Nitzschia sp.	2,688
	2. Melosira sp.	1,613
	3. Chromonas sp.	1,560
	4. Merismopedia sp.	1,236
	5. Microcystis sp.	753
	Other genera	5,428
	Total	13,277
05/23/74	1. Carteria sp.	7,682
	2. Nitzschia sp.	906
	3. Oscillatoria sp.	584
	4. Merismopedia sp.	409
	5. Melosira sp.	380
	Other genera	2,015
	Total	11,976
08/16/74	1. Oscillatoria sp.	35,327
	2. Nitzschia sp.	5,815
	3. Merismopedia sp.	4,615
	4. Anabaenopsis sp.	3,098
	5. Lyngbya sp.	2,445
	Other genera	15,441
	Total	66,741
11/06/74	1. Oscillatoria sp.	1,586
	2. Dactylococcopsis sp.	453
	3. Merismopedia sp.	198
	4. Lyngbya sp.	170
	5. Stephanodiscus sp.	170
	Other genera	1,219
	Total	3,796

B. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
03/14/74	1	30.9
	2	6.9
	3	23.6
05/23/74	1	6.8
	2	13.2
	3	6.9
08/16/74	1	21.6
	2	53.7
	3	40.1
11/06/74	1	23.1
	2	33.4
	3	-

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. March sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N & Ac. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.020	0.359	3.7
0.050 P	0.070	0.359	6.3
0.050 P + 1.0 N	0.070	1.359	16.9
1.0 N	0.020	1.359	4.1

b. November sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.021	0.117	2.1
0.050 P	0.071	0.117	1.6
0.050 P + 1.0 N	0.071	1.117	12.4
1.0 N	0.021	1.117	3.5

F. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Somerville Lake was high when the samples were collected (03/14/74 and 11/06/74). In the March sample, the increased yield resulting from the addition of orthophosphorus indicates phosphorus limitation at that time. However, in the November sample, the relatively small but significant increase in yield when nitrogen was added and lack of growth response when only orthophosphorus was added indicate nitrogen limitation.

The lake data support the assay findings. The mean inorganic nitrogen to orthophosphorus ratios were 15 to 1 in March, 25 to 1 in May, and 5 to 1 in November.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the month of April when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Middle Yegua Creek at station B-1 and the mean annual ZZ flow. Nutrient loads for the Brenham aqueduct were calculated using the mean flow provided by the District office of the U. S. Army Corps of Engineers (Howard, 1976) and the mean nutrient concentrations measured in Yegua Creek at station A-1.

The operators of the Lexington, Giddings, Rocky Creek State Park, and Big Creek State Park treatment plants did not participate; nutrient loads from these sources were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Lexington* (North plant)	400	stab. pond	151.4	Draw to Big Creek
Giddings*	3,400	stab. pond	529.9	Nails Creek
Big Creek State Park**	564	stab. pond	213.5	Somerville Lake
Rocky Creek State Park**	946	stab. pond	358.1	Somerville Lake

2. Known industrial - None

* Anonymous, 1977.
** Rennie, 1976.

B. Annual total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Middle Vegua Creek	7,725	30.9
East Vegua Creek	3,120	12.5
Nails Creek	2,530	10.1
Cedar Creek	1,180	4.7
b. Minor tributaries & immediate drainage (non-point load) -	4,965	19.8
c. Known municipal STP's -		
Lexington	455	1.8
Giddings	1,590	6.4
Rocky Creek State Park	1,075	4.3
Big Creek State Park	640	2.6
d. Septic tanks* -	6	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	1,730	6.9
Total	25,015	100.0

2. Outputs -

Lake outlet -	Brenham aqueduct	155
	Vegua Creek	16,680
	Total	16,835

3. Net annual P accumulation - 8,180 kg.

* Estimate based on three campgrounds (Rennie, 1976); see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Middle Vegua Creek	113,695	26.0
East Vegua Creek	63,200	14.4
Nail Creek	41,730	9.5
Cedar Creek	28,015	6.4
b. Minor tributaries & immediate drainage (non-point load) -	73,235	16.7
c. Known municipal STP's -		
Lexington	1,360	0.3
Giddings	4,760	1.1
Rocky Creek State Park	3,215	0.7
Big Creek State Park	1,920	0.5
d. Septic tanks* -	210	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	106,600	24.4
Total	438,140	100.0

2. Outputs -

Lake outlet -	Brenham aqueduct	2,515
	Vegua Creek	273,885
Total		276,400

3. Net annual N accumulation - 161,740 kg.

* Estimate based on three campgrounds (Rennie, 1976); see Working Paper No. 175.
** See Working Paper No. 175.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Middle Vegua Creek	7	101
East Vegua Creek	4	88
Halls Creek	14	230
Cedar Creek	10	227

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Fourmile Creek	0.031	1.016

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.54	0.18	9.4	3.5

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Somerville Lake:

"Dangerous" (eutrophic loading)	0.52
"Permissible" (oligotrophic loading)	0.26

V. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN ANALYSIS

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	SIO2 [illegible]	[illegible] CHLPA	15- [illegible]	[illegible] 1035 DAYS P
[illegible]	[illegible] LAKE	0.013	0.500	371.74	2.. .2	14.908	0.004
[illegible]	[illegible] LAKE	0.027	0.040	426.417	12.342	15.000	0.007
[illegible]	[illegible] RESERVOIR	0.026	0.115	378.312	8.625	15.000	0.007
[illegible]	[illegible] LAKE	0.134	0.150	461.625	22.762	14.850	0.042
[illegible]	[illegible] LAKE	0.027	0.100	470.375	4.887	.4.481	0.007
[illegible]	LAKE [illegible]	0.036	0.250	437.625	5.000	15.000	0.012
[illegible]	[illegible] LAKE	0.056	0.070	463.333	14.000	11.440	0.013
[illegible]	[illegible] LAKE	0.039	0.040	461.667	22.500	13.000	0.007
[illegible]	[illegible] RESERVOIR	0.018	0.450	384.812	2.500	14.000	0.007
[illegible]	LAKE [illegible] CITY	0.042	0.040	473.625	12.675	10.250	0.012
[illegible]	[illegible] CREEK LAKE	0.113	0.130	475.167	19.750	14.087	0.050
[illegible]	[illegible] LAKE	0.025	0.000	479.111	15.867	9.000	0.009
[illegible]	EAGLE [illegible] LAKE	0.054	0.070	469.625	5.662	13.000	0.000
[illegible]	FT [illegible] [illegible] LAKE	0.060	0.105	474.909	6.317	9.450	0.022
[illegible]	[illegible] LITTLE ELK RESERVO	0.045	0.300	475.782	14.156	14.600	0.010
[illegible]	[illegible] LAKE	0.023	0.110	455.000	10.217	10.400	0.007
[illegible]	[illegible] LAKE	0.097	0.250	486.167	10.650	12.400	0.036
[illegible]	LAKE OF THE PINES	0.031	0.090	448.000	12.014	15.000	0.011
[illegible]	[illegible] RESERVOIR	0.093	0.100	485.333	5.400	9.000	0.019
[illegible]	[illegible] LAKE	0.196	0.555	465.600	16.112	15.000	0.159
[illegible]	[illegible] & JOHNSON LAKE	0.042	0.420	458.500	6.100	14.900	0.013
[illegible]	[illegible] LAKE	0.018	0.100	483.562	12....	15.000	0.00
[illegible]	LAKE [illegible]	0.021	0.070	439.302	3.037	14....	0.009
[illegible]	PALESTINE LAKE	0.031	0.100	442.625	10.019	14.000	0.010
[illegible]	[illegible] [illegible] RESERVOIR	0.023	0.070	419.045	9.495	15.000	0.009
[illegible]	SAN [illegible] RESERVOIR	0.044	0.140	481.000	24.675	10.250	0.011
[illegible]	SAN [illegible] RESERVOIR	0.057	0.150	439.458	9.297	15.000	0.009
[illegible]	E O SPENCE RESERVOIR	0.036	0.275	462.587	11.775	15.000	0.009

LAKE DATA TO BE USED IN PARAMETRIC

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	SRP- REM REC	[illegible] CHLPH	[illegible] MIN DO	[illegible] DOSS [illegible] P
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PREVIEW OF LAKES WITH VIEWS VALUES RANKED BY LAKES WITH CLOSE VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL #	[illegible] INDEX #	[illegible] MEAN SIZE	[illegible] CHLORO	[illegible] [illegible]	[illegible] [illegible] [illegible] #	[illegible] [illegible]
401	[illegible] LAKE	45 (36)	5 (2)	188 (38)	143 (34)	39 (14)	42 (25)	40
402	[illegible] LAKE	75 (30)	74 (28)	72 (31)	47 (18)	17 (6)	92 (34)	343
403	[illegible] RESERVOIR	62 (35)	24 (10)	47 (37)	68 (24)	17 (6)	84 (32)	264
404	[illegible] LAKE	5 (2)	42 (16)	58 (19)	6 (3)	48 (17)	5 (2)	154
405	[illegible] LAKE	66 (25)	78 (29)	29 (11)	97 (33)	58 (22)	84 (30)	304
406	LAKE [illegible]	47 (18)	21 (7)	74 (28)	63 (24)	17 (6)	39 (14)	241
407	[illegible] LAKE	26 (10)	91 (33)	42 (16)	32 (12)	76 (29)	38 (10)	242
408	[illegible] LAKE	45 (17)	100 (36)	47 (18)	11 (4)	67 (25)	92 (34)	362
409	[illegible] RESERVOIR	98 (37)	8 (3)	95 (36)	47 (17)	44 (17)	97 (37)	445
410	LAKE [illegible] [illegible]	39 (14)	76 (28)	26 (10)	42 (16)	88 (23)	39 (14)	310
411	[illegible] [illegible] LAKE	8 (3)	47 (18)	18 (7)	13 (5)	61 (23)	8 (3)	155
412	[illegible] LAKE	69 (26)	83 (31)	32 (12)	29 (11)	97 (37)	63 (23)	372
413	EAGLE [illegible] LAKE	71 (27)	91 (33)	34 (13)	76 (30)	79 (30)	76 (28)	430
414	FT PARKER [illegible] LAKE	24 (9)	66 (25)	21 (8)	74 (28)	95 (36)	16 (6)	246
415	GARZA LITTLE ELM RESERVO	34 (13)	13 (5)	16 (6)	34 (13)	55 (21)	21 (7)	173
416	[illegible] LAKE	78 (29)	61 (23)	55 (21)	55 (21)	84 (32)	92 (34)	423
417	[illegible] LAKE	16 (6)	16 (6)	8 (0)	24 (9)	72 (27)	11 (4)	139
418	LAKE OF THE PINES	54 (20)	76 (29)	66 (25)	39 (15)	17 (6)	46 (17)	248
419	LAVON RESERVOIR	21 (8)	29 (11)	3 (1)	84 (32)	100 (38)	21 (7)	258
420	LEWISVILLE LAKE	3 (1)	3 (1)	39 (15)	26 (10)	17 (6)	3 (1)	91
421	LYNDON B JOHNSON LAKE	39 (14)	11 (4)	53 (20)	66 (25)	38 (14)	39 (10)	236
422	[illegible] LAKE	99 (37)	8 (0)	69 (34)	37 (14)	17 (6)	100 (38)	342
423	LAKE [illegible]	82 (31)	91 (33)	71 (27)	95 (36)	38 (14)	63 (23)	441
424	PALESTINE LAKE	54 (20)	32 (12)	62 (24)	53 (20)	48 (17)	51 (19)	302
425	[illegible] [illegible] RESERVOIR	74 (28)	91 (33)	84 (32)	58 (22)	17 (6)	63 (23)	387
426	SAN ANGELO RESERVOIR	13 (5)	46 (17)	8 (3)	0 (0)	88 (32)	46 (17)	208
427	SAN [illegible] RESERVOIR	59 (23)	38 (15)	68 (26)	76 (29)	17 (6)	63 (23)	302
428	E O SPENCE RESERVOIR	58 (19)	63 (23)	46 (17)	58 (14)	17 (6)	76 (28)	321

[illegible] OF LAKES WITH [illegible] VALUES. NUMBER OF LAKES WITH [illegible] VALUES

LAKE ID#	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	[illegible] [illegible]	[illegible] CHLA	[illegible]	[illegible]	[illegible]
[illegible]	SUMERVILLE LAKE	29 (117)	55 (223)	24 (97)	3 (11)	67 (251)	38 (183)	294
[illegible]	STAMFORD LAKE	18 (73)	47 (197)	5 (21)	18 (71)	62 (315)	39 (244)	254
[illegible]	STILLWATER [illegible] RESERV	68 (339)	37 (144)	67 (331)	42 (354)	17 (81)	51 (149)	372
[illegible]	TAMARACK LAKE	32 (127)	78 (283)	37 (144)	21 (83)	63 (244)	38 (183)	253
[illegible]	TEGAWAKA LAKE	11 (43)	51 (194)	13 (51)	16 (64)	72 (277)	13 (54)	176
[illegible]	TEHOMA LAKE	39 (164)	34 (133)	61 (233)	45 (177)	17 (81)	21 (71)	217
[illegible]	THAYER LAKE	68 (239)	21 (71)	42 (354)	62 (313)	17 (81)	84 (313)	[illegible]
[illegible]	THOMAS	0 (0)	66 (259)	11 (44)	5 (21)	42 (352)	8 (61)	154
[illegible]	TWIN WATERS RESERVOIR	59 (239)	21 (71)	58 (227)	61 (239)	44 (171)	63 (231)	311
[illegible]	WHITE RIVER RESERVOIR	84 (329)	61 (229)	76 (298)	66 (344)	17 (81)	41 (231)	348
[illegible]	WHITNEY LAKE	63 (246)	51 (199)	79 (309)	71 (279)	17 (67)	76 (298)	357

[illegible] RANKED BY INDEX NO.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	[illegible]	[illegible] RESERVOIR	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]

LAKES RANKED BY INDEX NO.

RANK	LAKE CODE	LAKE NAME	INDEX NO.
29	[illegible]	LYNDON B JOHNSON LAKE	259
30	[illegible]	TEXOMA LAKE	257
31	[illegible]	SOMERVILLE LAKE	254
32	[illegible]	SAN ANGELO (OCCIDENTAL)	248
33	[illegible]	TEMPLE LAKE	176
34	[illegible]	GRAPEVINE LITTLE ELM RESERVOIR	173
35	[illegible]	TRAVIS	169
36	[illegible]	GRANGE LAKE	159
37	[illegible]	CORPUS CHRISTI LAKE	155
38	[illegible]	HOUSTON LAKE	139
39	[illegible]	LIVINGSTON LAKE	46

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[illegible]

LAKE CODE [illegible] [illegible]

TOTAL DRAINAGE AREA OF LAKE(S) (MI) 2610.7

[illegible]	SUB-DRAINAGE AREA (MI)	JAN	FEB	MAR	APR	MAY	NORMALIZED FLOWS(CFS) JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
[illegible]	2610.7	2.49	7.39	18.31	12.69	14.26	18.19	4.23	2.28	2.32	3.14	6.17	4.28	6.13
[illegible]	1138.4	2.689	4.191	3.823	3.825	12.174	1.595	0.176	0.824	0.455	0.252	0.941	3.171	2.815
[illegible]	734.8	1.557	2.472	2.895	2.492	3.853	2.813	0.558	0.824	0.344	0.161	0.741	1.274	1.588
[illegible]	186.6	1.42	1.44	0.41	1.73	2.44	0.71	0.48	0.15	0.17	0.74	0.68	0.65	0.97
[illegible]	125.2	1.074	1.855	0.652	1.224	1.894	0.463	0.311	0.049	0.283	0.138	0.518	0.595	0.785
[illegible]	456.4	2.44	2.48	1.48	2.47	4.96	1.19	0.74	0.19	0.59	1.02	1.13	1.41	1.61

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 2610.7 TOTAL FLOW IN = 4.29
SUM OF SUB-DRAINAGE AREAS = 2609.8 TOTAL FLOW OUT = 78.35

[illegible] MONTHLY FLOWS AND ANNUAL FLOWS(CFS)

[illegible]	[illegible]	[illegible]	[illegible] FLOW	IRR	FLOW	IRR	FLOW	IRR	FLOW
[illegible]	0	A	22.378	0	14.935				
	10	A	36.877	7	74.477				
	11	A	32.281	4	8.886				
	12	A	4.776	0	13.988				
	1	B	8.865	12	24.527				
	2	B	19.435	2	6.142				
	3	B	15.611	29	8.048				
	4	B	2.564	26	6.199				
	5	B	13.459	13	6.133	10	27.751		
	6	B	44.174	28	21.239				
	7	B	33.487	15	26.996				
	8	B	18.589	30	8.823				
[illegible]	9	A	19.264	0	8.623				
	10	A	8.393	16	8.824				
	11	A	21.521	0	26.336				
	12	A	5.234	0	2.439				
	1	B	2.493	11	1.396				
	2	B	24.457	9	13.492				
	3	B	8.858	0	8.434				
	4	B	8.453	0	8.441	29	8.564		
	5	B	23.435	19	2.432				
	6	B	4.264						
	7	B	3.455						
	8	B	8.435	28	8.846				

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

| | | |

APPENDIX E

TRIBUTARY DATA

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	25	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	24	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	12	00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	25	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	04	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	09	00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	12	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]
[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	09	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	16	00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	21	00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	09	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

DATE FROM TO	TIME OF DAY	DEPTH OF FLOW	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.174	1.580	1.195	0.825	0.105
[illegible]	[illegible]	[illegible]	0.872	2.888	0.435	0.819	0.648
[illegible]	[illegible]	[illegible]	0.854	1.482	1.195	0.860	0.188
[illegible]	[illegible]	[illegible]	0.858	1.258	0.998	0.832	0.832
[illegible]	[illegible]	[illegible]	1.045	1.388	0.840	0.885	0.846
[illegible]	[illegible]	[illegible]	0.843	1.288	1.299	0.825	0.286
[illegible]	[illegible]	[illegible]	0.815	1.588	0.845	0.815	0.858
[illegible]	[illegible]	[illegible]	0.150	1.258	0.698	0.815	0.248
[illegible]	[illegible]	[illegible]	0.148	0.958	0.138	0.815	0.868
[illegible]	[illegible]	[illegible]	0.845	1.888	0.138	0.815	0.878

[illegible]

[illegible]
[illegible]
[illegible]

[illegible]

[illegible]

DATE FROM TO	TIME OF DAY	DEPTH FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
74/10/07	13	30	0.824	0.468	0.646	0.622	0.128
74/11/04	16	00	0.884	1.798	1.198	0.838	0.246
75/01/12	13	30	0.872	1.169	0.934	0.816	0.660
75/02/02	11	10	0.824	0.788	0.646	0.888	0.410
75/03/27	16	10	0.885	1.496	0.975	0.885*	0.819
75/04/13	11	15	0.815	0.796	0.646	0.815	0.438
75/04/28			0.815	0.168	0.642		0.816
75/05/18			0.838	1.468	0.825	0.815	0.428
75/06/29	16	10	0.826	0.458	0.638	0.838	0.858
75/07/15	11	10	0.815	0.858	0.646	0.815	0.438
75/08/19	11	30	0.815	1.868	0.115	0.829	0.846

* VALUE KNOWN TO BE LESS THAN INDICATED

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]